Geographic Information System Approach to Trails Management in Shenandoah National Park, Virginia.

Dan Hurlbert, GIS Specialist

The park's GIS assisted with trails damage assessment following two significant events; Hurricane Fran in September, 1996 and a major ice storm in January, 1998. Horizontal inaccuracies in the GIS trails layer led to a parkwide mapping and assessment project. Backcountry resource management specialists and trails maintenance supervisors met with students and staff from James Madison University, Virginia, to discuss the project details. Assessment criteria included in the discussions, a need to qualitatively measure trail degradation factors such as erosion and vegetative encroachment. Also, identified were needs to know where the concentration of down trees and debris are most evident and the number, condition and locations of bridges, retaining walls and cribbing.

Feature data collection using satellite-mapping technology (GPS), students hiked and mapped each trail and associated trail features including 463 sections along 331 miles of trail (534 km). Also mapped were 152 culverts, 71 retaining walls and 18 bridges. Other information gathered included low-water stream crossings, trail intersections and numbers of water control features (WCF). Water control is important, especially along trails. Often, a trail will act as a conduit for water during storm events of the type mentioned. Channels result as erosion carries the structural integrity of the trail bed down slope. Water control features such as checkdams, waterbars and culverts are important impediments to this process.

Although it is important to know the locations of WCF's, many sections of trail, or reaches, contain hundreds of certain types of these features. It was determined early in the mapping and assessment processes that a tally would suffice for these. Others, such as culverts, retaining walls and cribbing were individually mapped with GPS, measured and overall condition assessed.

Low-water stream crossings, trail intersections and permanent landmarks along reaches were also located using GPS. Many of these control points were used in defining reachbreaks. Reachbreaks, as used in the context of this article, are entities along a trail's defined path that segment a trail into sections with internally unique attributes and are reproducibly recognized by two or more distinct individuals. They allow viewing trails data at a higher resolution since many trails contain up to eight definable reaches. Therefore, information from the database can be viewed at up to eight times the resolution for certain trails. As many as 120 positions (PDOP < 6.0) were collected and post-processed into control points which will also be useful in future GIS/imagery integration.

Present analyses of the data support no conclusion concerning horizontal accuracies of these mapped features. Previous studies in Shenandoah National Park determining accuracies for multi-positional, point data suggest a three to eight meter horizontal variance under certain conditions. This range is further supported by GPS equipment specifications which estimate two to five-meter horizontal map accuracies (Deckert and Bolstad, 1996; Trimble, 1996).

Trails Database Management Design

The database consisted of three spatial layers and four external tables linked in a relate environment. Geographic Information System coverages included trails, reachbreaks and control points. Feature attributing determined which external databases could be accommodated in the final database design. The National Park Service's Maintenance Management System (MMS), a proposed Computerized Backcountry Management System (CBMS), Recreational Opportunity Classes (ROC) and recreational use were determined of immediate concern to design team members. Unique identifiers that would link to these external datasets were entered into the data dictionary of a portable datalogger connected to GPS mapping equipment (Fig 1, Appendix 1).

A spatially correct trails layer is now available for park operations requiring accurate base layers. When linked to the external trails database management system, the visual information contained on maps will assist maintenance crews in determining where maintanence needs are greatest. The nature of a mountainous trail system, is continual erosion. Many sections of trail contain hundreds of water control features attempting to slow this process. Each requires a certain standard of maintenance. These standards depend on several factors, including type and level of recreational use (horse trail, hiking trail), whether the trail is within legislatively designated wilderness, or the designated use area (ROC) through which the trail passes. ROC's are established to preserve discrete recreational experiences across broad regions of parkland (Bair and others, 1998) (Fig 2).

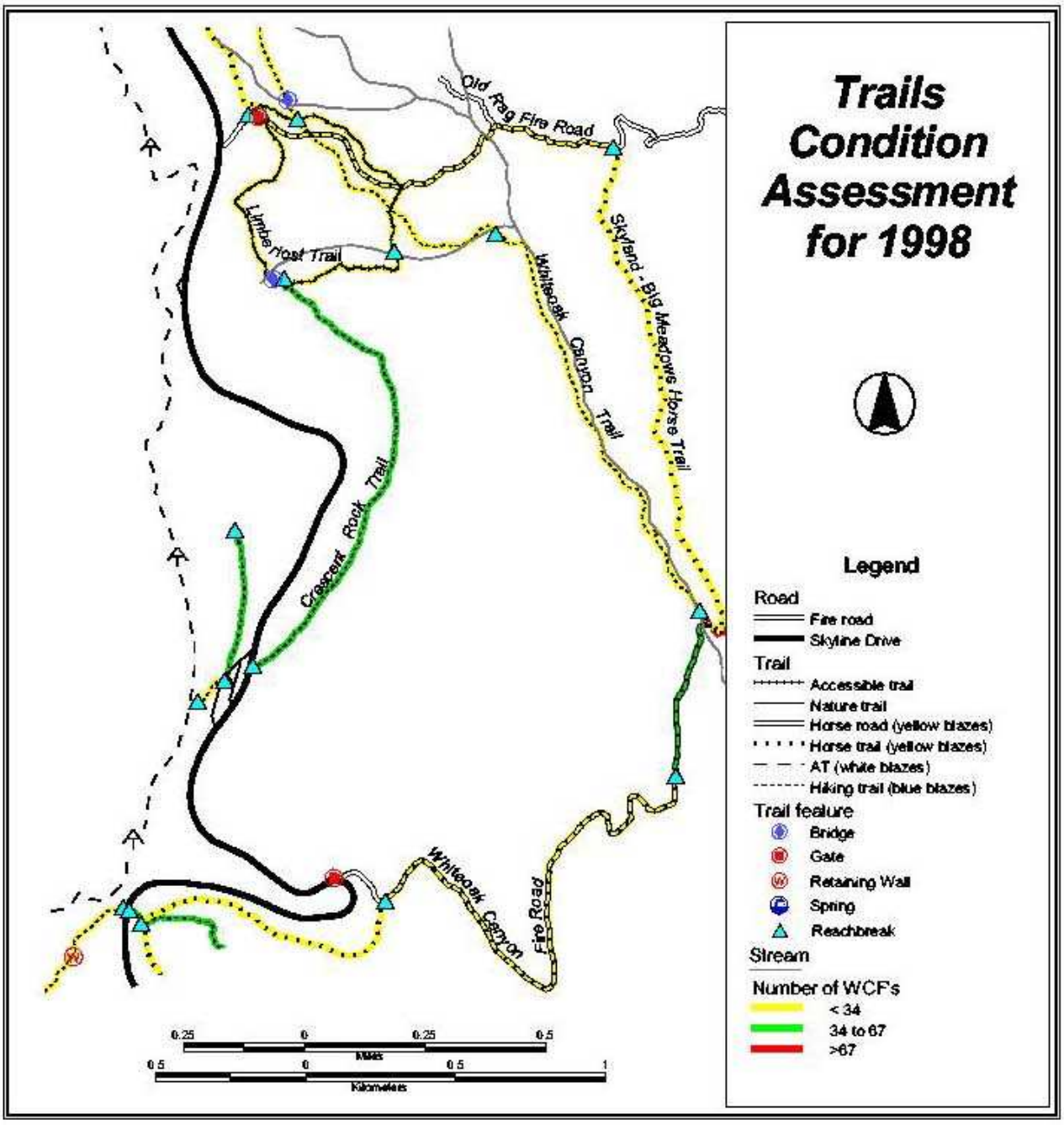

Figure 2. This map was produced from the trails data management system using information collected during the 1998 trails assessment project. Trails are displayed showing the number of water control features (WCF) within each reach. The Appalachian Trail, represented by a large dashed line symbol, was not evaluated during this phase of the project.

The trails database management system is available to accurately evaluate and report trail condition following future storm events. As a storm's impact is complete, trail assessment staff will measure resource impacts. Updates of these impacts can be viewed as data is entered into the database. Damage reports with accurate assessment maps will be available within weeks of a major storm rather than months. GIS maps will provide information of specific trail construction needs to restore trails to pre-incident condition (Fig 3).

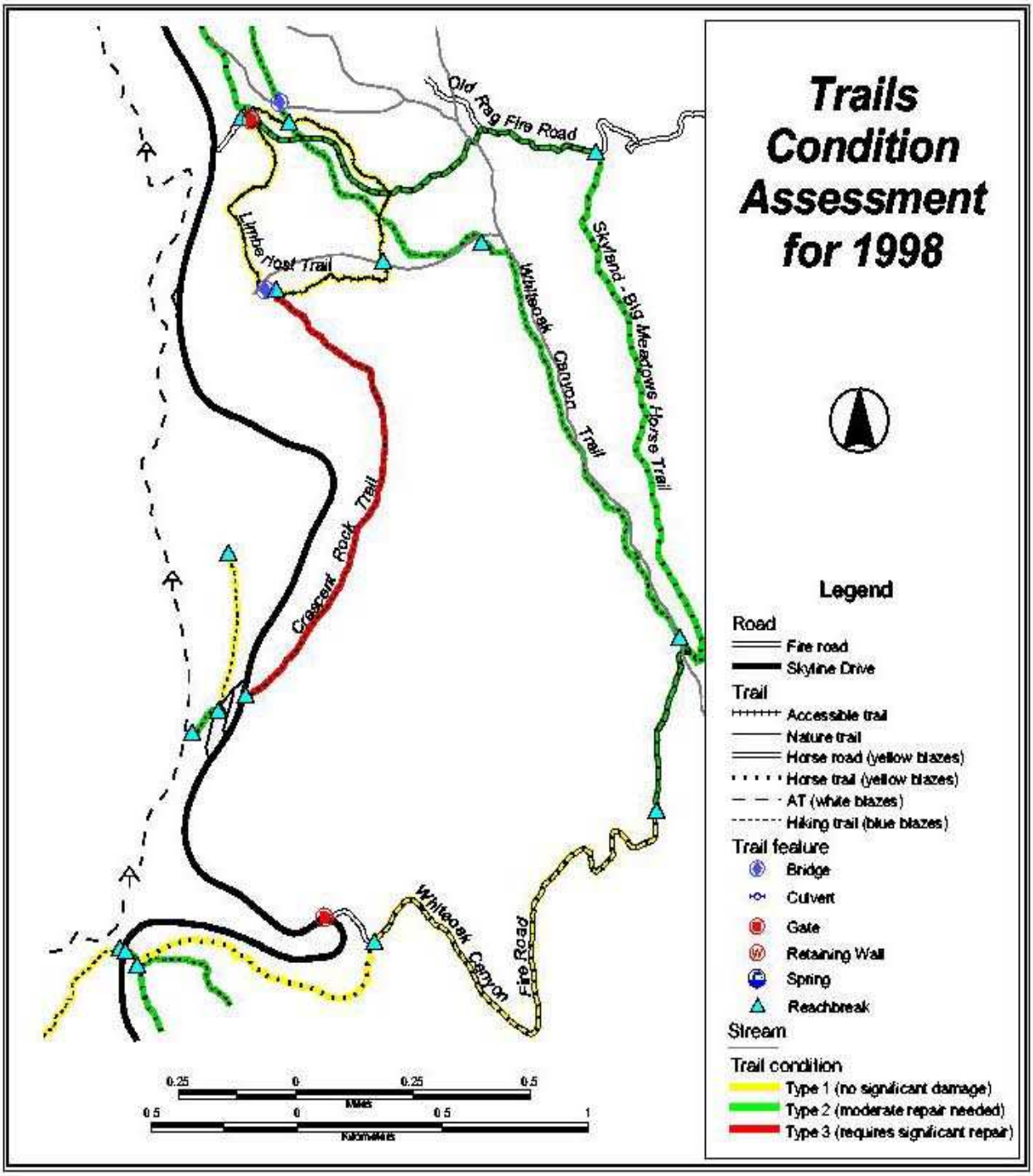

Figure 3. This map was produced from the trails data management system using information collected during the 1998 trails assessment project. Trails are displayed showing the type of recreational use and overall condition. The Appalachian Trail, represented by a large dashed line symbol, was not evaluated during this phase of the project.

More current trails information on visitor use site bulletins should result in higher visitor satisfaction. Last seasons (1998) visitor comments record issues that can only be addressed using more accurate trail data. (Shenandoah National Park, 1999) (Fig 4).

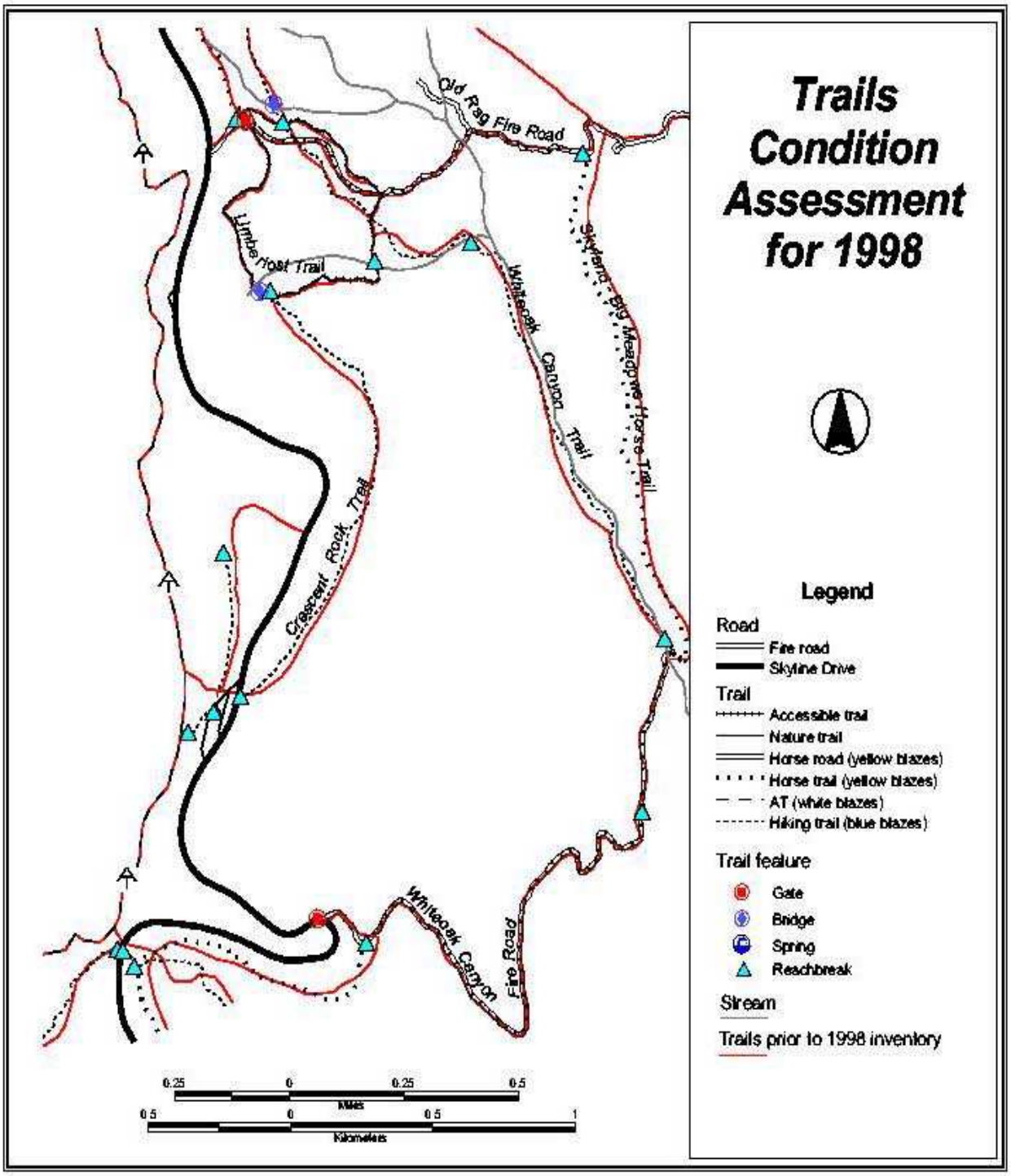

Figure 4. This map was produced from the trails data management system using information collected during the 1998 trails assessment project. Trails are displayed showing the type of recreation use overlayed with the original trails layer digitized form 1:62,500 scale maps. The Appalachian Trail, represented by a large dashed line symbol, was not evaluated during this phase of the project.

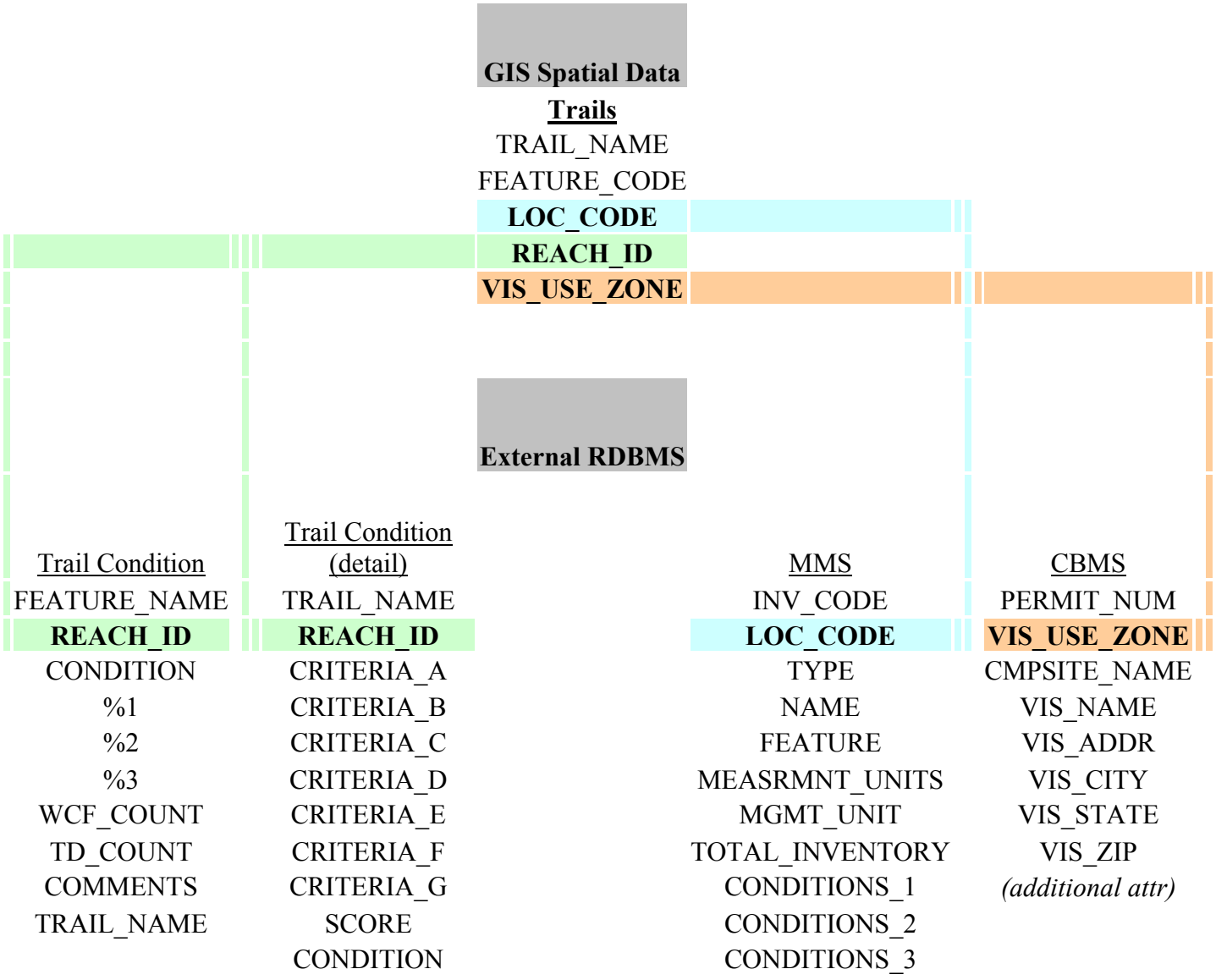

Figure 1. Data attribute tables for GIS trails coverage and associated external data management systems. Green line joining trails reach_id to external trails condition tables results from 1998 assessment. Blue line represents potential link to the park's Maintenance Management System. Red line is the proposed link to a future Computerized Back- country Management System. See Appendix 1for attribute definitions.

Bibliography

Bair, S., Green, S., Lindsay, T., Stiles, G., Dems, J., Shannon, L., Snyder, H., and Hesselbart, R., 1998, Shenandoah National Park, Backcountry and Wilderness Management Plan. pp. 8.1-8.10.

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Appendix 1: Attribute Definitions

GIS Coverages

TRAILS: (trails layer)

TRAIL_NAME: (item name used to identify trail name)

FEATURE_CODE: (item name used to identify trail type or designed use) 101 (accessible trail), 102 (nature or discovery trail), 103 (horse or yellow blaze road), 104 (horse or yellow blaze trail), 105 (Appalachian Trail), 106 (hiking or blue blaze trail), 107 (abandoned trail due to reroute).

LOC_CODE: (item name used to identify location) (USDOI-NPS, 1992)

REACH_ID: (Identification code assigned to unique section of trail) REACH_ID is a concatenation of loc_code and a sequential number beginning with – (dash) 01at Skyline Drive and increasing with value toward the Park boundary.

VIS_USE_ZONE: (Three digit code related to backcountry permit zones/trail codes) provides link to Recreation Opportunity Class (ROC) mapping and the Computerized Backcountry Management System) ROC's are designated use areas established to preserve discrete recreational experiences across broad regions of parkland. CBMS monitors visitor uses through backcountry permit applications.

TR_RBRK: (trail reachbreak)

RBRK_TYPE: (Item name used to identify the type of reachbreak) Typical reachbreaks names include Trailhead, Cement post, Stream crossing, Rock outcrop, Trail intersection, Gate, Culvert or Bridge. RBRK_NUM (Concatenation of location code and a sequential number beginning with – (dash) 01) COMMENT (Generalized descriptive information for each reachbreak)

CTRL_PTS: (control points)

FEATURE_NAME: (Item name used to identify the type of control point)

LOC_CODE: (Item name used to identify location) (USDOI-NPS, 1992)

SITE_ID: (Concatenation of location code and a sequential number beginning with – (dash) 01) COMMENT (Generalized descriptive information for each control point)

External Tables

TRAILS: (general)

REACH_ID: (As defined by trails layer)

CONDITION: (Overall condition of trail reach determined by condition classification matrix) %1 (Percent of reach mapped with a condition score 1) %2

(Percent of reach mapped with a condition score 2) %3 (Percent of reach mapped with a condition score 3)

WCF_COUNT: (Number of water control features tallied along a specific reach)

TD_COUNT: (Number of trees downed along a specific reach)

COMMENTS: (Descriptive information concerning a trails reach)

TRAIL_NAME: (As defined by trails layer)

TRAILS: (detail)

TRAIL_NAME: (As defined by trails layer)

REACH_ID: (As defined by trails layer)

CRITERIA_A: (Score representing extent of trail degradation due to erosion within a reach)

CRITERIA_B: (Score representing the condition of water control features within a reach)

CRITERIA_C: (Score representing the number of downed trees within a reach) CRITERIA_D (Score representing the width of vegetative encroachment as allowed within a specific designated use area)

CRITERIA_E: (Score representing the number of standing dead trees adjoing a specific reach)

CRITERIA_F: (Score representing the condition of retaining walls and rock cribbing within a reach)

CRITERIA_G: (Score representing the condition of Bridges with a reach)

SCORE: (Numeric value related to the sum of all criteria evaluated for a specific reach)

CONDITION: (Overall condition of trail reach determined by condition classification matrix)

RBRK: (reachbreaks)

REACH_ID: (as defined by tr_rbrk layer)

COMMENT: (Detailed descriptive definition for each reachbreak)

SITES: (control points)

SITE_ID: (as defined by ctrl_pts layer)

MATERIAL: (construction material for retaining walls, bridges or culverts)

LENGTH: (length of feature if retaining wall, bridge or culvert)

WIDTH: (width of feature if retaining wall, bridge or culvert)

HEIGHT: (height of feature if retaining wall, bridge or culvert)

CONDITION: (overall condition of feature if retaining wall, bridge or culvert) COMMENTS (Detailed descriptive information for each control point)

TRAIL_NAME: (As defined by trails layer)

External Table Being Compiled:

SITE_STAT: (statistical data for each control point)

AVG_PDOP: (a dimensionless value representing the geometric average of positional location using Global Positioning System technology)

SDEV: (statistic of positional accuracy)

VARI: (statistic of positional accuracy)

ELEV: (elevation using height above ellipsoid model for calculating position)

UTMX: (Universal Transverse Mercator coordinate system, Northing)

UTMY: (Universal Transverse Mercator coordinate system, Easting)

LATN: (North Latitude in DMS)

LONGW: (Western Longitude in DMS)

DATE: (Data collection date, mm,dd,yyyy)